Development of a new tool for the prediction of fruit juices microfiltration performance

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Outlines

Context and aim of the work

Scientific strategy

Results and discussion

1. Juices physicochemical characterization
2. Juices filterability tests
3. Statistical analysis
4. Prediction of fruit juices filterability

Conclusion

Context of the work

Consumption of fruit juices and drinks containing fruit juices

Industrial
- Thermal treatments

Consumer
- Safe product
- Fresh-like quality

Cross-flow microfiltration

Membrane permeability diminution

Membrane fouling

Predicting and controlling juice filterability

Aim of the Work

Most of publications

Optimization approaches and strategies

Pre-treatment and/or conditioning of juices to be filtered

Lack of knowledge

Mechanisms

Study the possibility of predicting fruit juices filterability according to some of their intrinsic characteristics

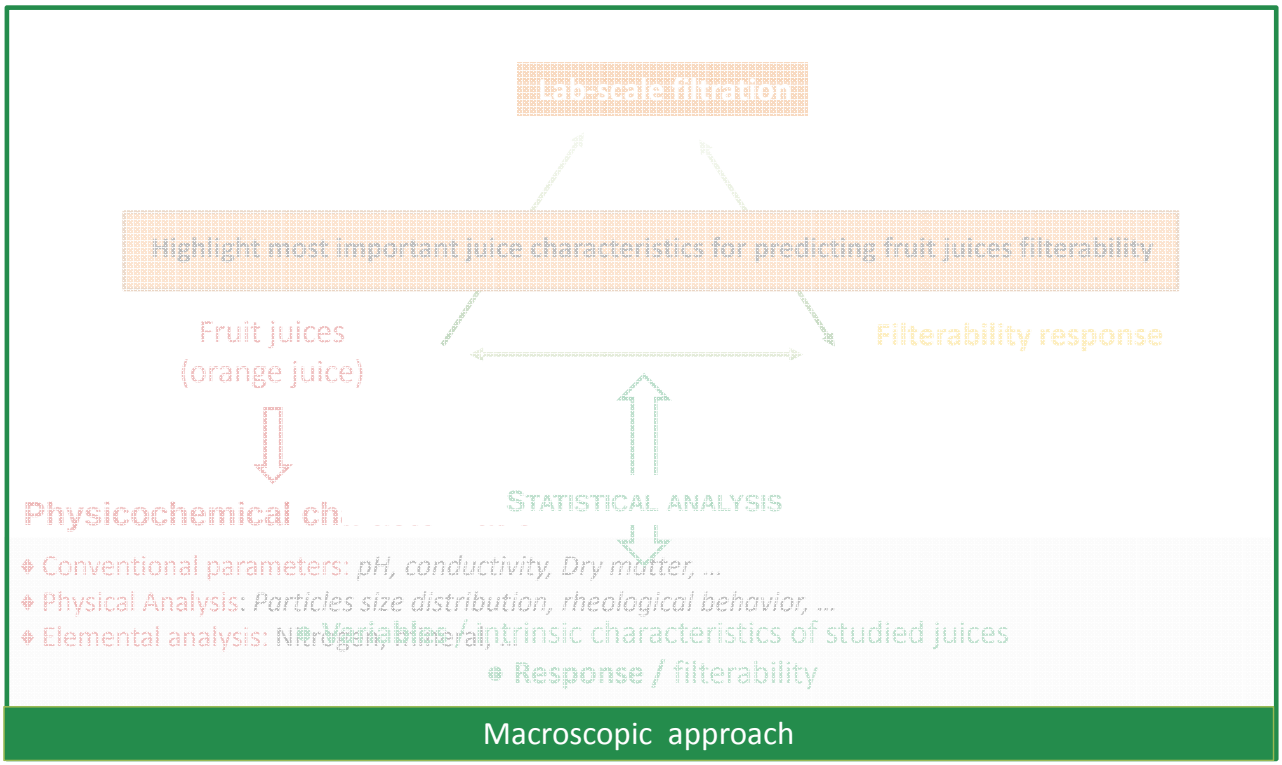
Lab-scale study

Develop a simple and fast juice filterability prediction tool

Choose the suitable approach for enhancing microfiltration

Potentiel industrial application

Scientific strategy



Juices physicochemical characterization

Juices selection

Nine different commercial brands of orange juices

Stored at -20°C and defrosted before use at 4°C/one night

Studied parameters

conventional	Total soluble solids (TSS), suspended insoluble solids (SIS), dry matter (DM), total acidity (TA), pH, conductivity, turbidity

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Physical measurements	Particle size distribution, rheological behavior, capillary suction time

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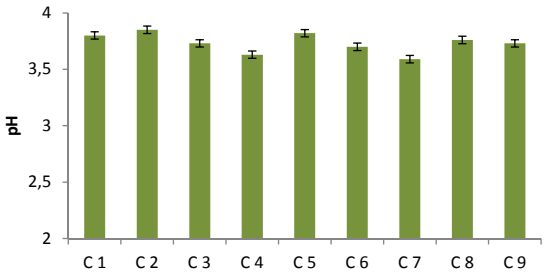
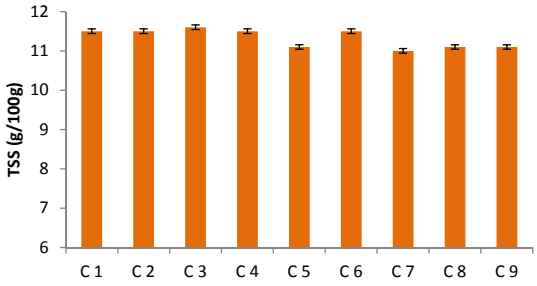
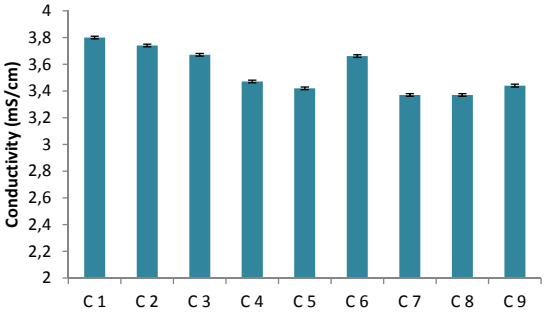
Physical measurements	Particle size distribution, rheological behavior, capillary suction time
Elemental analysis	Nitrogen (N), Phosphorus (P), K^+, Cl^-, Na^+, Ca^{2+}, Mg^{2+}

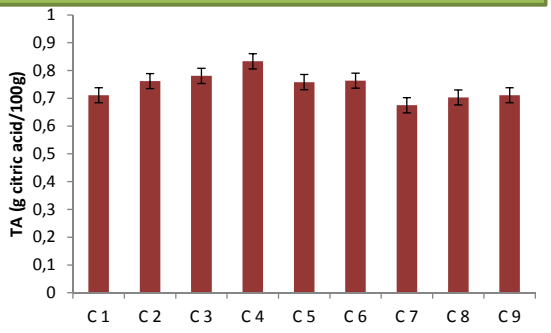
Conventional parameters



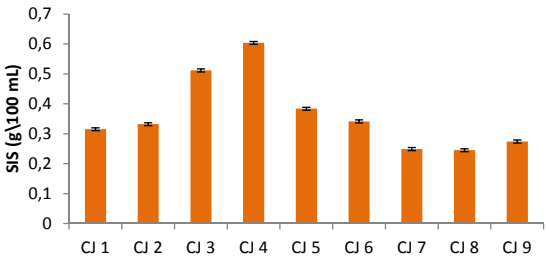


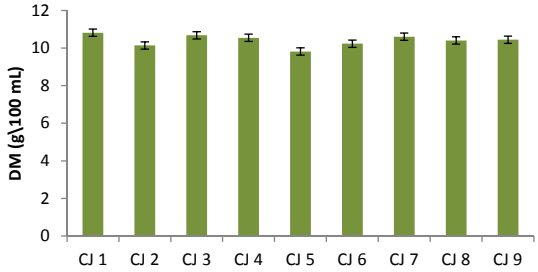
Values of these attributes were in the range of those previously reported for commercial orange juices

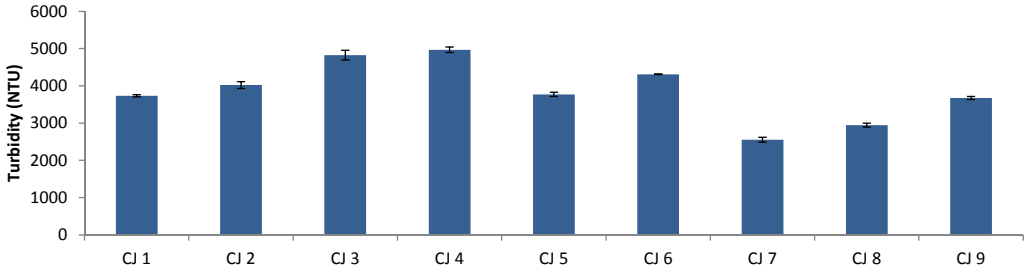




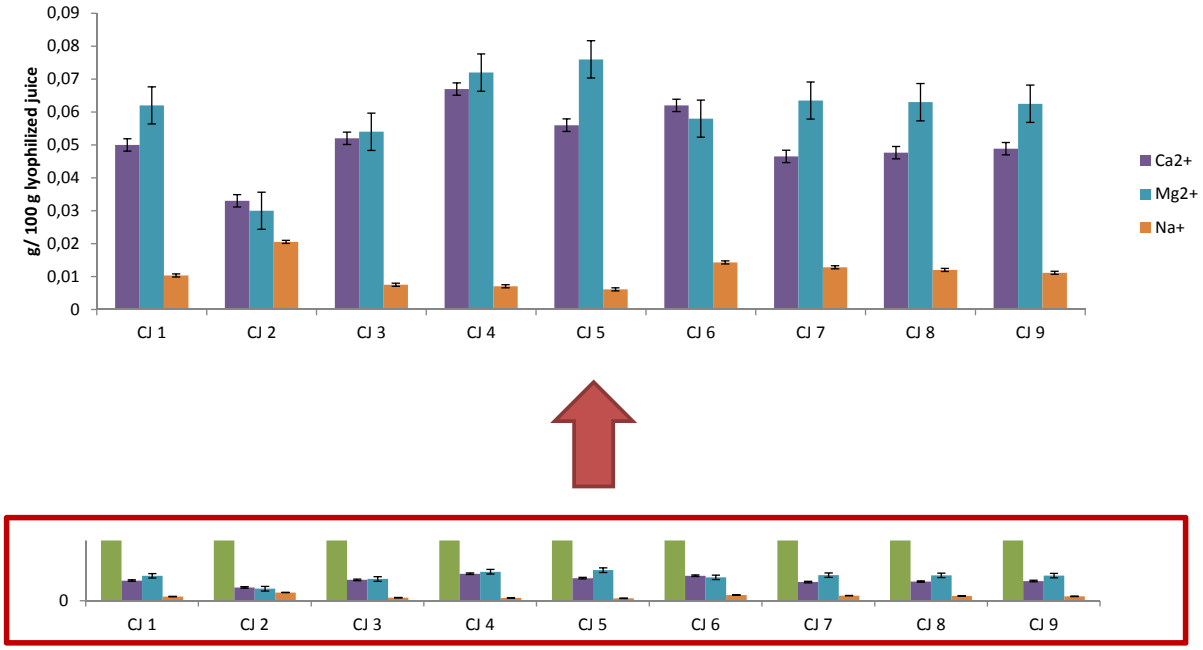
Conventional parameters







Elemental analysis



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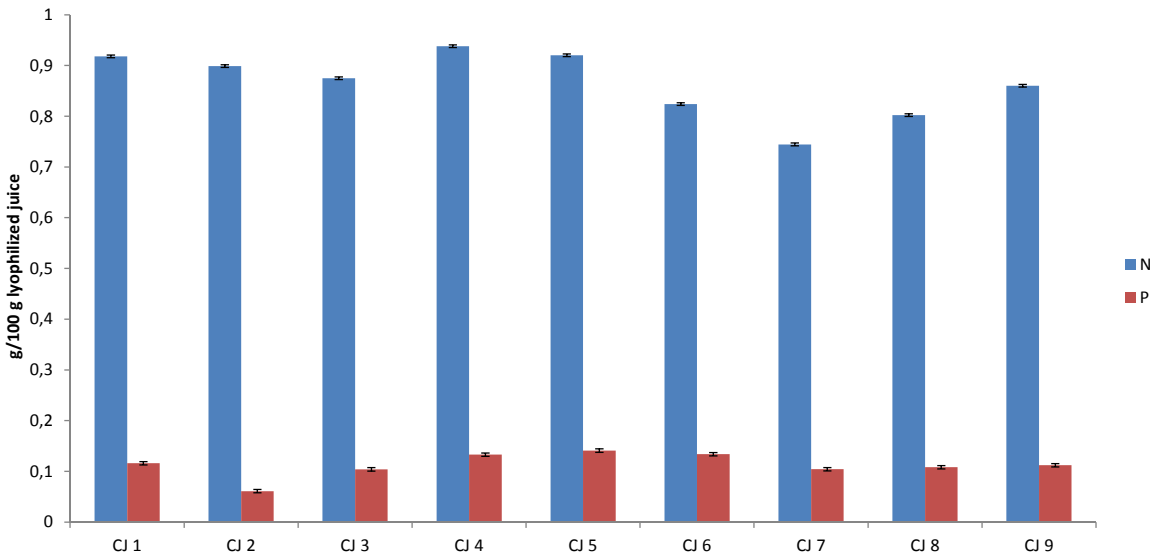


Particle size measurement

Equipement

Laser diffraction, Malvern Mastersizer 3000

Refractive Indices 1,33 (water) 1,73 (cloud particles)

Absorption index 0,1 (cloud particles)

Measurment method

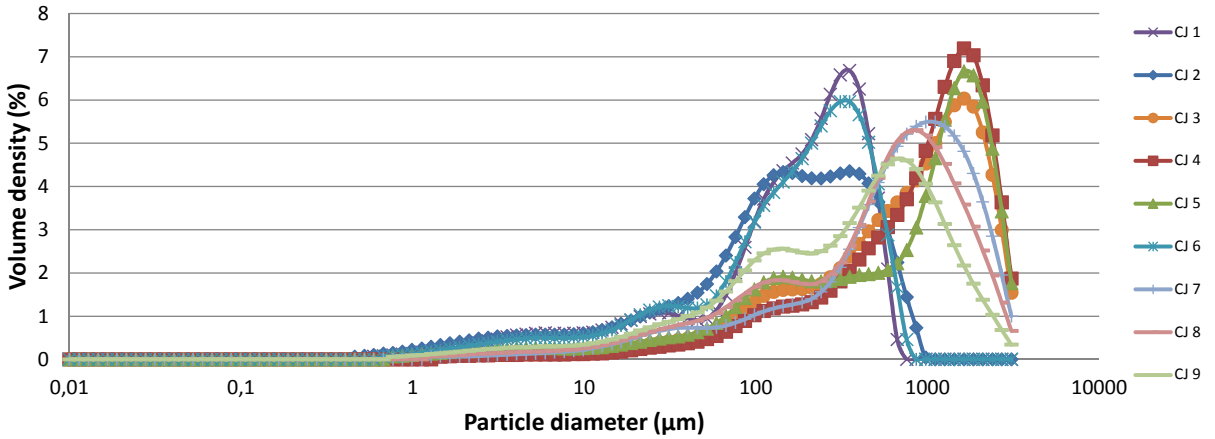
42% Obscuration

1500 rpm

$$D[3.2] = \frac{\sum_i n_i d_i^3}{\sum_i n_i d_i^2}$$

n:number of particles

d:diameter of particles



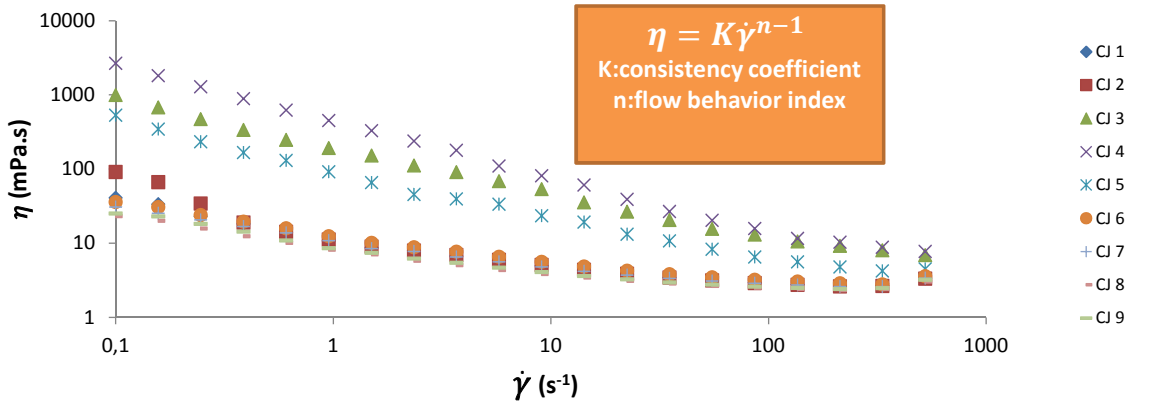
Jus	CJ 1	CJ 2	CJ 3	CJ 4	CJ 5	CJ 6	CJ 7	CJ 8	CJ 9
D[3.2]	27,3	21	100	138	52	30,7	100	81	51

Rheological behavior

$$\eta = K\dot{\gamma}^{n-1}$$

K:consistency coefficient

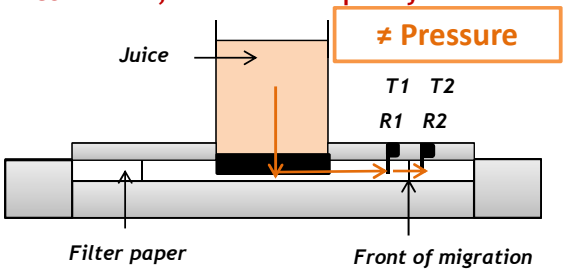
n:flow behavior index



Juices	CJ 1	CJ 2	CJ 3	CJ 4	CJ 5	CJ 6	CJ 7	CJ 8	CJ 9
K	12,6	12,2	197,9	440,3	96,6	13,4	8,9	9,7	11,5
n	0,6	0,6	0,4	0,3	0,4	0,6	0,3	0,3	0,3

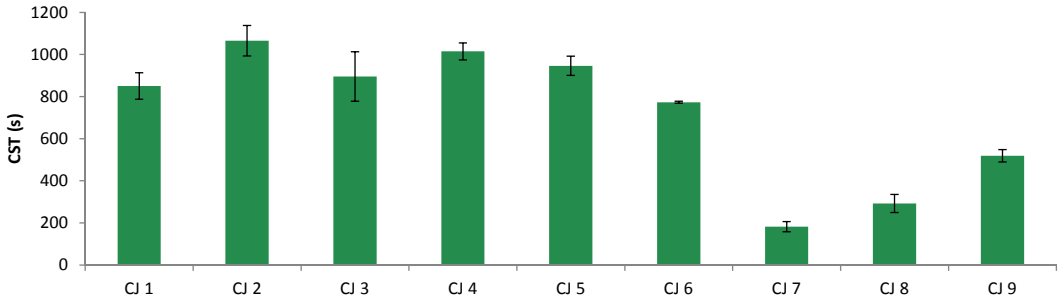
Capillary suction time

CST-meter, measure of capillary suction time



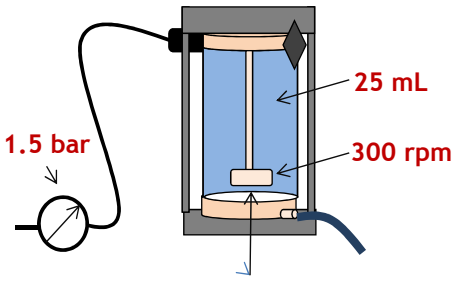
CST= T2-T1

- **Originally developed for assessing sludge filterability and industrial suspensions (Gale and Baskerville, 1967, (Ruiz et al., 2010)**
- **Not yet tested for fruit juices**



Juices filterability tests

Filtration cell

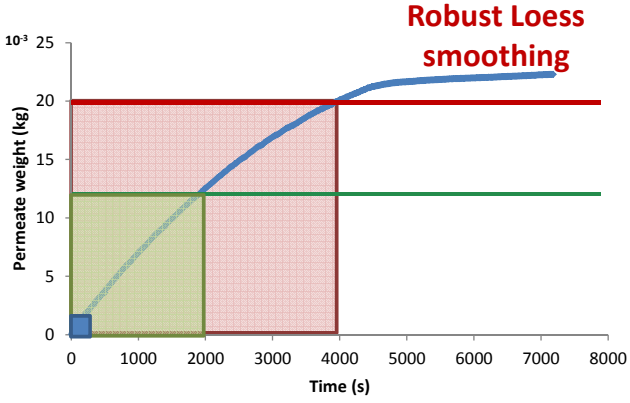


Glass fiber membrane 1.2 µm

Evaluate the filterability of the studied juices

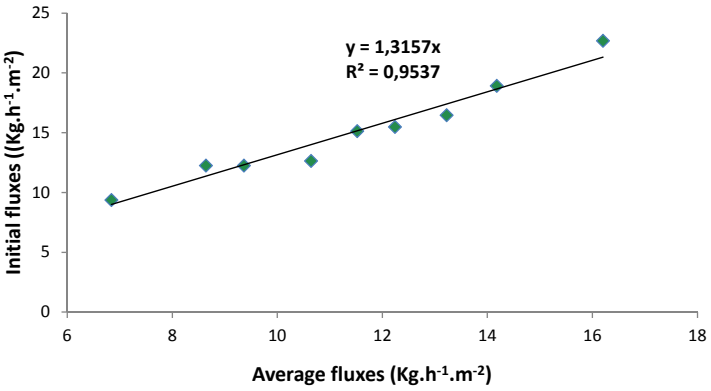
$$J_{(kg.h^{-1}.m^{-2})} = \frac{dm}{dt}\frac{1}{S}$$

$\overline{J}_{i(kg.h^{-1}.m^{-2})}$ First minute



Juices filterability tests

Juices	CJ 1	CJ 2	CJ 3	CJ 4	CJ 5	CJ 6	CJ 7	CJ 8	CJ 9
Average Fluxes ($Kg.h^{-1}.m^{-2}$)	8.6	12.3	6.8	9.5	16.3	11.4	10.6	13.2	14.2
Initial Fluxes ($Kg.h^{-1}.m^{-2}$)	12.1	15.6	9.5	12.2	22.8	15.1	12.6	16.5	18.9



- **Initial fluxes were used as the only filterability response variable in the statistical analysis**

Statistical analysis

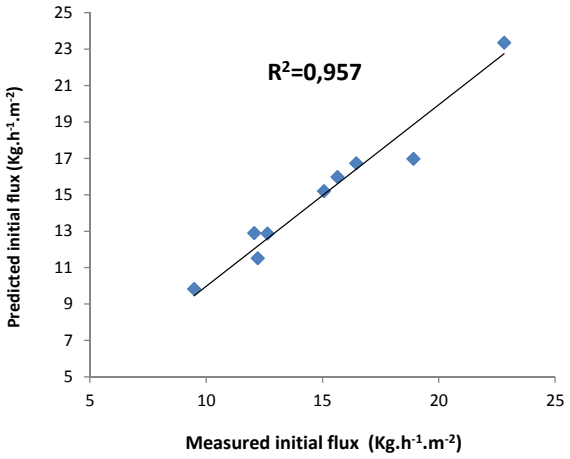
Predictor variables > sample number

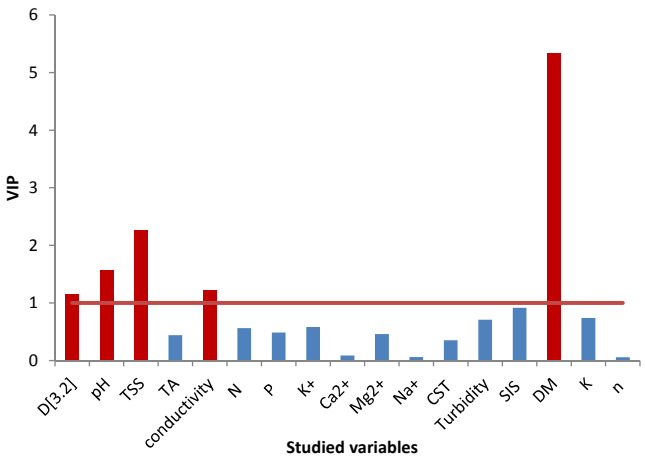
Variables correlated

→ **PLS (Partial Least Squares regression)**

model-wise method (Afanador et al., 2013)

PLS-VIP method (Afanador et al., 2013)



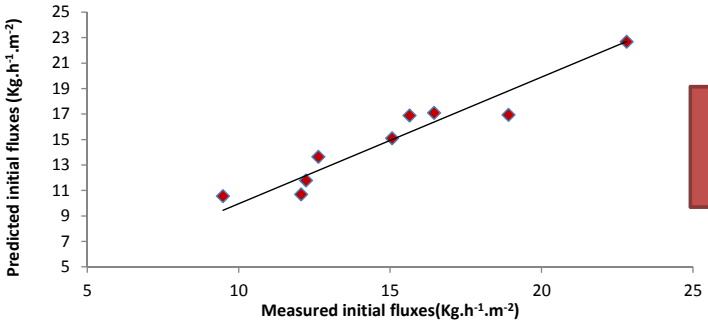


Statistical analysis and Prediction of fruit juices filterability

Predictor variables > number of samples

Variables correlated

→ **PLS (Partial Least Squares regression)**



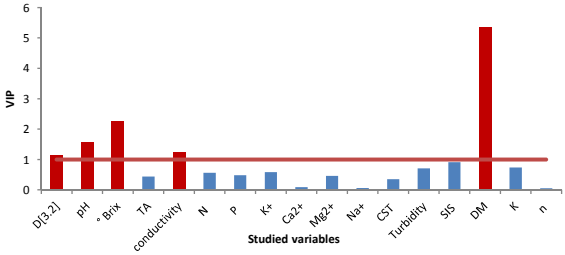
Leave-one-out cross-validation test (LOOCV) (Cawley and Talbot, 2004)

Number of samples	Number of variables	Mean of the measured initial fluxes	RMSEC	RMSECV	R^2
9	17	15.0	0.79	2.10	0.957
9	5	15.0	1.06	2.09	0.923

RMSEC et RMSECV < 20 % of the mean (Bikindou et al., 2012)

Conclusion

It is possible to predict juices filterability according to their intrinsic characteristics



Filterability can be satisfactorily predicted according to Only five simple predictor variables

Possibility of extrapolating this strategy to industrial scale since the selected variables are simple and fast to measure

Thank you for your attention